SpaceSim
Orbiter Docking Simulation
Operations Manual

12-02-05

An Educational Product of the National Aeronautics and Space Administration

(This manual applies to SpaceSim Version # 2.5.6)

(Manual Revision 1.3)

SpaceSim Users Manual

Table of Contents:

1.0 Introduction

SpaceSim is an immersive and interactive Space Simulation that accurately reproduces the sights, sounds, and challenges that actual astronauts experience as they rendezvous and dock with the International Space Station. SpaceSim immerses students in the cockpit of the Space Shuttle Orbiter and provides them with realistic scenery, displays, and controls that enable them to rendezvous and dock successfully. SpaceSim can also immerse students outside the Space Shuttle Orbiter simulating an interactive spacewalk experience.

SpaceSim is an educational simulation designed to inspire present, and future generations of explorers to develop a life-long interest in learning and discovery.

2.0 System Requirements

The following minimum requirements are required to run SpaceSim:

- A Pentium 4, 1.7 GB computer running Windows2000 or Windows XP
- 512 MB of memory
- 200 MB free disk space
- A Open-GI Video Card with 128 MB onboard memory (ATI & Nvidia have been tested but others should work too)
- A mouse or Trackball (For user navigation)
- A 3-axis Joystick w/integrated (or separate) throttle (For Orbiter engine firing)
- A display device (CRT/LCD monitor, VisionStation, LCD/DLP projector, Plasma display, etc …)

If you wish to implement Virtual Reality Capability …
- A Head-Mounted Display
- An Ascension Technology or Polhemus tracker
- A Video Splitter (1 Input channel -> 3 Output channels)

See Appendix 2 for a basic system block diagram.

3.0 Understanding how the Orbiter docks with the International Space Station

Because SpaceSim accurately recreates the basic procedure for an actual docking of the Orbiter to the International Space Station, it is helpful to learn how an actual docking is performed by NASA Astronauts.

The Space Shuttle Orbiter's Rendezvous and Docking with the International Space Station actually begins with the precisely timed launch of the Space Shuttle from the Kennedy Space Center in Florida. During the first two days, periodic engine firings will gradually bring the Orbiter to a point about 9-1/2 miles behind the International Space Station, the starting point for the final approach.

The final approach begins about 3-hours before scheduled docking on the third day of the mission. The crew will power on the Orbiter Docking System (ODS) and activate the Orbiter's docking lights. Then, the orbiter's jets will be fired in a Terminal Initiation (T1) burn to begin the final phase of Rendezvous. As the Orbiter closes in, the Rendezvous Radar will be activated to provide range and closing rate information. During the approach, the shuttle will have an opportunity to make four small, mid-course correction maneuvers. At about 1 hour before scheduled docking, the Orbiter's commander will take over manual control of the approach from the AFT Flightdeck. The commander will maneuver the Orbiter to a point about 600 feet from and directly opposite the Station's docking port (Pressurized Mating Adapter). From this point on, the commander will begin closing in on the docking port at a speed of one-tenth of a mile per hour. Using a view from a TV camera mounted in the center of the Orbiter's docking mechanism, as a key alignment aid, the commander will precisely center the docking ports of the two spacecraft. At 30 feet from the station, the commander will stop the approach for a few minutes to check final alignment. The commander will maintain the shuttle's speed relative to the station at about one-tenth of a foot per second, and keep the docking mechanisms aligned to within 3 inches of one another. When the Orbiter makes primary contact with the station, preliminary latches will automatically attach the two spacecraft together. Immediately after docking, the Orbiter's steering jets will be deactivated to reduce the forces acting on the docking interface.

4.0 Comparing a SpaceSim simulation to an actual docking scenario

SpaceSim accurately recreates the final approach and docking of the Space Shuttle Orbiter to the International Space Station. However, in order to make this experience enjoyable and educational for youthful participants without lots of training, some elements have been modified from an actual docking experience. This section describes SpaceSim's similarities and differences to an actual Rendezvous and docking performed by NASA Astronauts.

Creating the experience of "being there"

Only a handful of astronauts have had the unique experience of piloting the Orbiter to a precise rendezvous and docking with the International Space Station. While no simulation on Earth can substitute for the authenticity of actually "being there", SpaceSim utilizes a variety of techniques to provide a similar experience.

SpaceSim immerses participants within the Space Shuttle Orbiter's Flightdeck or out in Space. As can be seen below, the participant's onscreen view of the virtual-world simulates that of an astronaut. Participants are able to walk around the Orbiter Flightdeck to peer out of any of the available Windows (FWD, AFT, and AFT-Overhead) (Using their Mouse or Trackball) to view their approach to the International Space Station, or to help align the two docking ports in preparation for docking. Participants are also able to place themselves outside the Orbiter where they will be free to go on a virtual spacewalk. SpaceSim enables participants to follow in an astronaut's footsteps as they rendezvous and dock with the International Space Station.
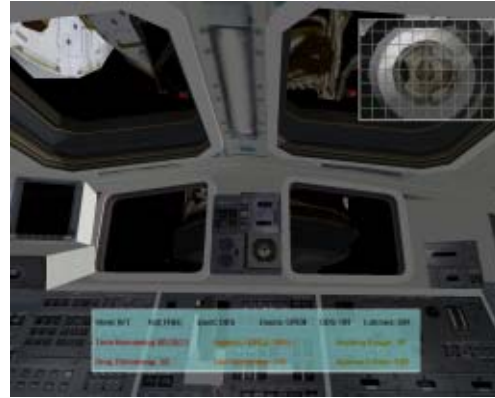
Engine Firing

Participants have complete control of the Orbiter's Reaction Control (RCS) engines in order to perform rotational or translational maneuvers as required to rendezvous and dock with the International Space Station. However, unlike the actual Orbiter, which utilizes separate controls for rotation and translation, these two functions are controlled by a single joystick. In an attempt to make engine firing more realistic, a mode ("Medium" skill level) has been implemented to recreate Newton's laws of motion when firing engines. However, it is pretty challenging to fly the Orbiter in this mode because the combination of numerous engine firings could impart a motion on the Orbiter that is difficult to counteract. For this reason, a more kid-friendly "Easy" skill level has been implemented that eliminates the effect of Newton's laws and makes maneuvering much easier. Obviously, during an actual rendezvous and docking by NASA Astronauts, it's impossible to eliminate the effect of Newton's laws, but sophisticated computers, instrumentation, and a dedicated support team on Earth make the task of maneuvering the Orbiter look easy.

Displays and Controls

Some of the displays and controls used in SpaceSim have been simplified and reduced in complexity to make them more kid-friendly so they can be easily understood by a participant/astronaut without requiring extensive training. Amazingly, participants who use SpaceSim will utilize most of the same Rendezvous and Docking Aids that NASA astronauts use during an actual docking such as the Centerline camera display, the Attitude Direction Indicator, the DEMOS display, the FWD, AFT, and AFT-Overhead window views, and a display that indicates your range and approach rate to the target docking port. Some of these displays have been modified to make them more kid-

friendly but their basic function is still the same as during an actual docking scenario by NASA. Astronauts. An example of how one such instrument was modified can be seen with the Attitude Direction Indicator or ADI. While this instrument looks similar to the NASA counterpart and also functions the same, an additional marking has been added to indicate to participants when the two docking ports (on the Orbiter and ISS) are perfectly aligned for docking. While this additional marking, and the use of it to determine rotational alignment are not used during an actual Space shuttle Rendezvous and Docking mission, it does demonstrate NASA's extensive reliance on instrumentation in order to safely and accurately perform a docking in Space.

Authentic Procedures

Most of the same procedures required during an actual docking have been retained in SpaceSim. For Instance, participants still have to press a button to Open the Orbiter's Payload bay before they are able to dock, or before they can even see their view from the Orbiter's centerline camera. If this is not done, the Orbiter will crash into the ISS's Pressurized Mating adapter while trying to dock, possibly ending the mission. Participants also have to press a button to turn on Orbiter Docking System Power prior to docking. If this is not done, the Orbiter will crash into the ISS Pressurized mating adapter when attempting to dock even if the two docking ports are perfectly aligned, possibly ending the mission.

Damage

SpaceSim provides the ability to select how much damage is allowed before the mission fails. Damage is always caused by colliding with the International Space Station. Obviously, an actual space mission would have a zero tolerance for damage and causing such damage to occur will likely have serious consequences. For the highest level of realism as compared to an actual mission, set this number to "1" in the setup screen so the mission will end at the first crash.

**Additional Enhancements not provided during an actual mission**

Several enhancements have been added that add value and interest to the simulation. Voice synthesis has been included to confirm the operation of most of the switch functions (Payload bay doors open/closed, ODS power ON/OFF, etc …) and also to announce status.

5.0 Installing SpaceSim

Installing SpaceSim is very easy. Whether SpaceSim is downloaded or received on CD, click on the file "SpaceSimInstall" on the disk or in the directory where it has been downloaded. SpaceSim will be automatically installed in the default "C:" directory (which can be changed if desired) and will then create a shortcut on the desktop and a shortcut in the Start menu. In addition, a Quick reference card, and this document (The full operating instructions) can be displayed by going to "Start" – "All Programs" – "SpaceSim" as can be seen on the next page.

The Adobe Acrobat Reader is required for viewing or printing either the Users Manual, or the Quick Reference Card. Acrobat Reader can be downloaded free at www.adobe.com
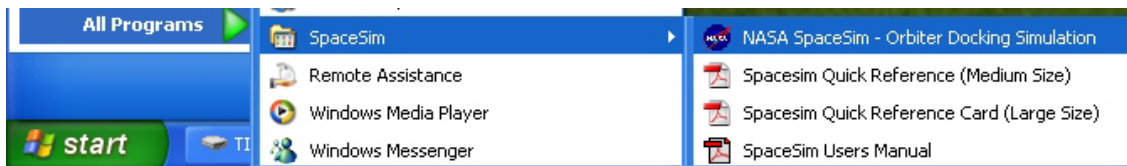
6.0 SpaceSim Startup

Left-click twice on the "NASA SpaceSim" icon, or click "Start" – "All Programs" – "SpaceSim – "NASA SpaceSim" – Orbiter Docking Simulation" and SpaceSim will begin loading. During the startup process, three popup windows will be displayed that enable SpaceSim to be customized as explained next. It is normally OK to accept the defaults but if something needs to be changed, the following instructions explain how.

6.1 Regular Screen Setup

SpaceSim supports three different display configurations that can be selected or changed within the "Screen Setup" dialogue box. This setting sets the resolution and field-of-view of the SpaceSim display and will vary depending on the resolution and type of monitor or other display device used. During SpaceSim operation, a user can cycle through these three configurations that are listed below by pressing "w". In actual use, only one configuration will normally be needed unless SpaceSim is part of a traveling exhibit were several different types of displays will be used.

Normal – Originally for a 4:3 aspect monitor, but customizable
Wide – Originally for a 13:9 aspect widescreen monitor, but customizable.
Dome – Originally for a Wrap-Around display from Elumens, but customizable.
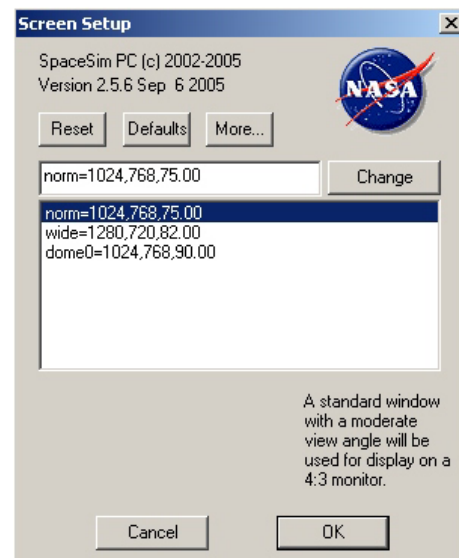
To Select a display configuration

To select a specific screen configuration, simply click on it to highlight it as shown above and then click [OK].

To change a display configuration

1) Click on the specific screen configuration that is to be changed – Either Normal, Wide, or Dome. It will be highlighted as shown below. This screen configuration will be displayed (copied) in the box to the left of the "Change" button.
2) Type in the box to replace the existing values with the new values just as you would in any word processor.
- The first number (1024 in the previous example) is the horizontal resolution of the SpaceSim Window (in pixels).

- The second number (768 in the previous example) is the vertical resolution of the SpaceSim Window (in pixels).
- The third number (75.00 in the previous example) is the view angle in degrees.

To fill the screen, the horizontal and vertical resolution must match the "screen resolution" that your computer is set at. To determine your screen resolution, right-click on the desktop, then select "Properties" and then "settings". If SpaceSim is run on a slower machine, chose a lower resolution such as 800 X 600.

3) Click "Change"
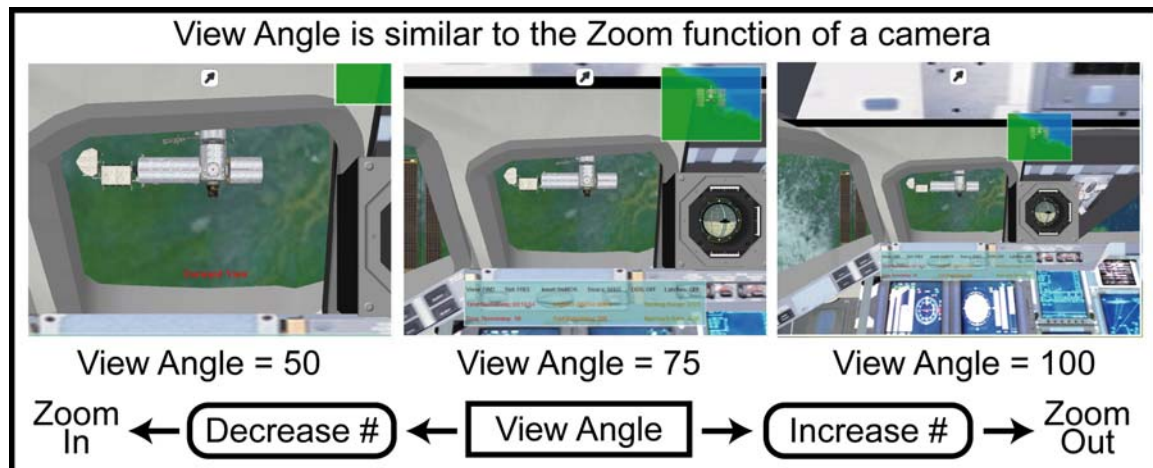Repeat steps 1-3 to change another preset before continuing if desired.

4) Click "OK" to continue.

Click "Defaults" to return to a set of known, good configuration settings.
Click "Reset" to discard the changes just made without exiting this window.
Click "Cancel" to exit to Windows without making any changes

The view angle sets the field-of-view of the on-screen image for the Participant. As can be seen in the illustration below, View angle works just like the Zoom function of a camera. If the view angle is changed, the Position, and size of the Inset Window and Display Panel will likely have to be adjusted too. A 75 degrees view angle is a good number to use when using a regular CRT or LCD display.

View Angle is similar to the Zoom function of a camera

View Angle = 50   View Angle = 75   View Angle = 100

Zoom In ← (Decrease #) ← View Angle → (Increase #) → Zoom Out
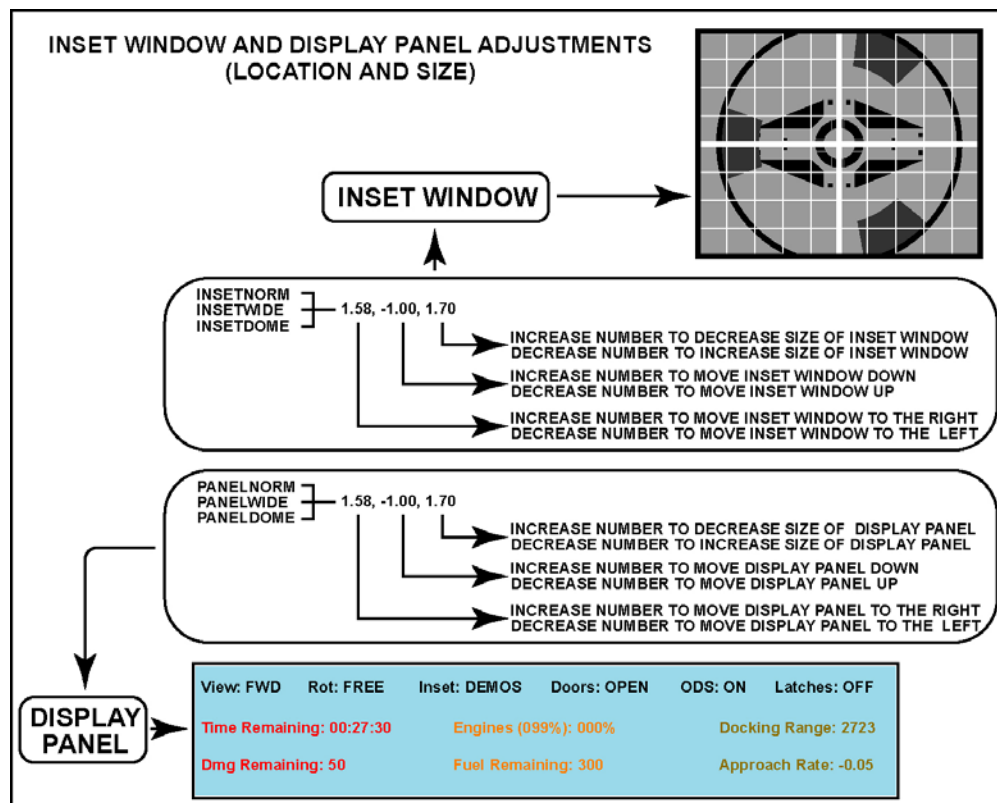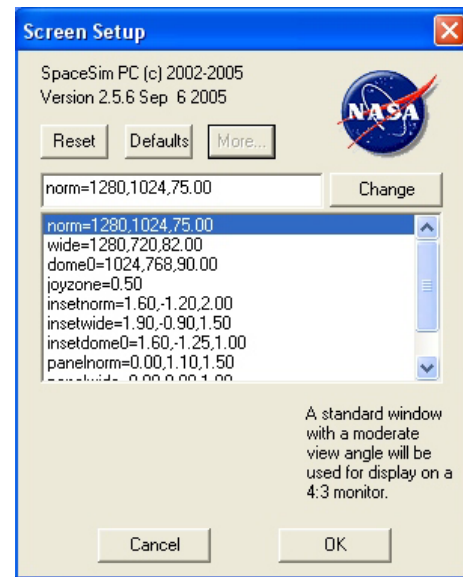
Advanced Screen Setup

Clicking on the "More" button brings up the "Advanced" parameters as shown on the next page.

The "Advanced" parameters enable the size and location of the display panel and inset window to be customized. Customizing the size and location of the display window and inset window may be required whenever changing display resolutions and is especially helpful when using SpaceSim with non-standard or special display devices such as Plasma Displays, LCD projectors and the VisionStation Hemispherical Dome Display. The Advanced screen setup also enables the joystick dead zone to be set to prevent erroneous and inadvertent engine firing caused by low cost and noisy joysticks.

The following parameters are available for you to change …

Joyzone – This parameter sets the joystick dead zone. This number should be increased if the engines fire without moving the joystick. This number can vary between 0 (No Dead Zone) to 1 (100% dead zone) in .01 steps (Ie. .15, .23, etc). The Joystick should always be calibrated with software from the manufacturer first before making dead zone changes within SpaceSim. Software calibration may be all that is required. If Dead Zone changes are needed, only the smallest number should be used that provides good results.

Refer to the drawing below to understand how to change the position and size of the Inset window (Insetnorm, Insetwide, Insetdome), and the Display Panel (Panelnorm, Panelwide, and Paneldome).

Screen Setup

SpaceSim PC (c) 2002-2005
Version 2.5.6 Sep 6 2005

Reset   Defaults   More...

norm=1280,1024,75.00   Change

norm=1280,1024,75.00
wide=1280,720,82.00
dome0=1024,768,90.00
joyzone=0.50
insetnorm=1.60,-1.20,2.00
insetwide=1.90,-0.90,1.50
insetdome0=1.60,-1.25,1.00
panelnorm=0.00,1.10,1.50
panelwide=0.00,0.00,1.00

A standard window with a moderate view angle will be used for display on a 4:3 monitor.

Cancel   OK

INSET WINDOW AND DISPLAY PANEL ADJUSTMENTS (LOCATION AND SIZE)

INSET WINDOW

INSETNORM
INSETWIDE   1.58, -1.00, 1.70
INSETDOME

INCREASE NUMBER TO DECREASE SIZE OF INSET WINDOW
DECREASE NUMBER TO INCREASE SIZE OF INSET WINDOW

INCREASE NUMBER TO MOVE INSET WINDOW DOWN
DECREASE NUMBER TO MOVE INSET WINDOW UP

INCREASE NUMBER TO MOVE INSET WINDOW TO THE RIGHT
DECREASE NUMBER TO MOVE INSET WINDOW TO THE LEFT

PANELNORM
PANELWIDE   1.58, -1.00, 1.70
PANELDOME

INCREASE NUMBER TO DECREASE SIZE OF DISPLAY PANEL
DECREASE NUMBER TO INCREASE SIZE OF DISPLAY PANEL

INCREASE NUMBER TO MOVE DISPLAY PANEL DOWN
DECREASE NUMBER TO MOVE DISPLAY PANEL UP

INCREASE NUMBER TO MOVE DISPLAY PANEL TO THE RIGHT
DECREASE NUMBER TO MOVE DISPLAY PANEL TO THE LEFT

DISPLAY PANEL

View: FWD	Rot: FREE	Inset: DEMOS	Doors: OPEN	ODS: ON	Latches: OFF
Time Remaining: 00:27:30		Engines (099%): 000%		Docking Range: 2723	
Dmg Remaining: 50		Fuel Remaining: 300		Approach Rate: -0.05	

Insetnorm – These parameters set the position and size (X, Y, Z) of the inset Window for the "Normal" display configuration.

Insetwide - These parameters set the position and size (X, Y, Z) of the inset Window for the "Wide" display configuration.

Insetdome - These parameters set the position and size (X, Y, Z) of the inset Window for the "Dome" display configuration.

Panelnorm - These parameters set the position and size (X, Y, Z) of the Display panel for the "Normal" display configuration.

Panelwide - These parameters set the position and size (X, Y, Z) of the Display panel for the "Wide" display configuration.

Paneldome - These parameters set the position and size (X, Y, Z) of the Display panel for the "Dome" display configuration.

There are not really any set limits for the Inset Window and Display Panel Position and Size. The limits are determined by the screen resolution, the view-angle, and even the position and size of the windows themselves. A rule of thumb is to set these values in .1 degree increments, gradually using larger increments as the operator becomes more familiar with how far each increment causes the panels to move. Same procedure is used to change the size of the panels. This is largely a trial-and-error process at first that rapidly becomes fairly quick and easy. If a number is entered that causes either window to disappear from view completely, press "Defaults" to return to a known, good configuration and try again.

6.2 Sensor Setup Dialogue box

The "sensor" setup dialogue box as shown at right enables SpaceSim's input devices (HMD, Joystick, etc …) to be configured.

The Head Tracker is used to provide a fully immersive SpaceSim experience when used with a Head-Mounted display (HMD).

"Head" tracker settings (For advanced users only)

Type – selects the type of Head Tracker (Either Ascension, Polhemus, or None) If the head tracker is not used, select "None". This is the default.

Port – Selects the serial port on the computer that the tracker is connected to (Either COM1 or COM2)

Baud – Selects the data rate of the serial port that the tracker is connected to.
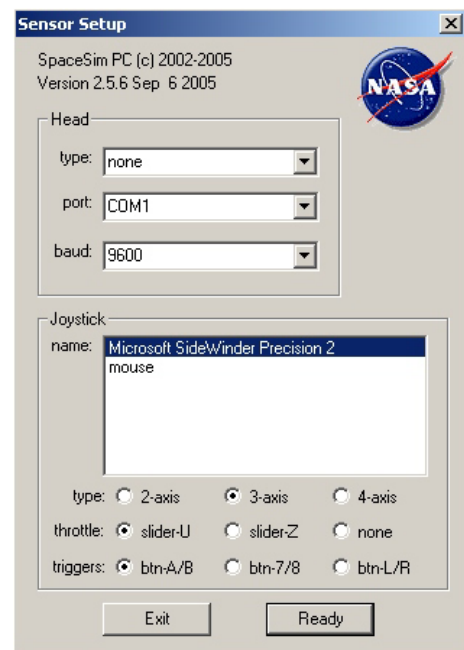
Refer to Appendix 2 for a block diagram of a virtual reality/head-mounted display system.

Joystick settings

The Joystick settings enable the joystick devices to be customized.

All of the joystick devices that are connected to the system at the time SpaceSim is run are listed in this box. A mouse and trackball are also considered a joystick device so they are listed if they are connected too.

All joysticks are listed first and then mice/trackballs so if only one joystick is connected, just accept the default, which is the first device, listed.

Type: Select the type of Joystick connected to the computer. Select 2-axis, 3-axis, or 4 axis. These types are fully explained below.

NOTE: For the most realism and ease of operation, a 3-axis joystick is preferred since this type most closely approximates the operation, look, and feel of the Rotational Hand Controller aboard the Orbiter.

Joystick types: See below …

2-Axis Mouse – Regular 2-button Mouse – A regular 2-Axis Mouse. Movement of the Mouse Left, Right, Forard, and Back in combination with pressing one or both of the mouse buttons are required to move and rotate the Orbiter in 3 dimensions.

2-Axis Joystick – Joystick moves Forward, Back, left, and Right. Several additional buttons are required to move and rotate the Orbiter in 3 dimensions. This joystick should have a hat switch (a 4-position rocker switch on top) at the top of the joystick to enable the changing of views but if it doesn't, the keyboard keys F1 and F2 could be used to change views instead.

3-Axis Joystick – This is the preferred controller. It is the easiest and most intuitive and is most similar to the Rotational Hand Controller used onboard the Orbiter. The Trigger is the only other button required to move and rotate the Orbiter in 3 dimensions. This joystick should have a hat switch (a 4-position rocker switch) at the top of the joystick to enable the changing of views but if it doesn't, the keyboard keys F1 and F2 could be used to change views instead.

Usage of a 4-Axis Joystick is experimental and not recommended.

Joystick Throttle:

Most Joysticks use "U" though some use "Z". If the joystick has noisy values or is in awkward combination with another axis, it can be disabled. Throttle control on the joystick is not required as it can be done by pressing "+" and "-" on the keyboard to increase or decrease thrust. You should always use the default value for "Joystick Triggers" unless the throttle doesn't work correctly, than you could try a different setting as shown on the next page.

Joystick Triggers:

A/B – The first two (Or 1 if 3-Axis) buttons are used for position/orientation control. The remaining buttons are used for simulation control.

7/8 – The Left and Right trigger buttons for a game controller are used, allowing 1-6 for simulation control.

L/R – The Left and Right Under-Thumbstick buttons are used, allowing 1-6 for Simulation Control.

6.3 Mission Setup Dialogue box

The mission setup dialogue box shown below/right enables many parameters of a simulation to be customized. By changing various parameters such as the time limit, the fuel available, the amount of damage allowed, the skill level, etc …, the operator can tailor the simulation to a specific mission scenario, or a specific age group/skill level. The possibilities are endless. Here are only a few examples. See below.

- If SpaceSim will be used at an event or facility where a large number of participants have to fly in a limited time, their flying time could be limited by setting the Time limit from 1-30 minutes (Per Participant) just to give each a taste of what docking the orbiter is like. It should be noted that docking is a very slow process in a real Space Mission so rushing students to a docking is not recommended if the highest realism to an actual mission wishes to be maintained.

- If mentally or physically challenged students are to fly SpaceSim, the skill level could be set to "Easy" and damage could be set to "Unlimited" if students have difficulty operating the controls.

- If Spacesim is used to simulate an actual docking scenario performed by NASA astronauts, the Orbiter's initial position with respect to the International Space Station and/or the Orbiter's orientation (Pitch, Roll, Yaw) can be configured precisely.

- If any participant flying SpaceSim wishes to be challenged, the skill level could be set to "Normal". This setting will add acceleration to the Orbiter whenever engines are fired.
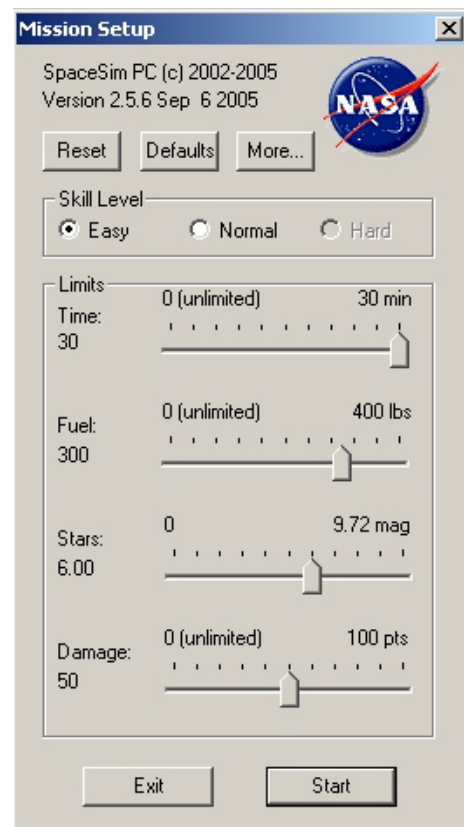
The mission setup dialogue box contains commonly used settings, and advanced settings.

Common settings – The common "Mission Setup" settings are shown and described next.

Skill Level – The skill level determines the way the motion of the Orbiter is affected by engine firings. Selecting "Easy" mode moves the Orbiter whenever the joystick is moved away from its "center" position. The Orbiter stops moving when the joystick is returned to its "center" position. Selecting "Normal" adds acceleration to the Orbiter's motion when the joystick is moved away from its "center" position so that the Orbiter continues moving after the joystick is returned to its center position. In "Normal" mode, the Orbiter moves and accelerates according to Newton's laws of motion. "Normal" is a very challenging mode that demonstrates some of the challenges actual astronauts face while trying to dock the Orbiter with the International Space Station. To be successful at docking while in "Normal" mode, it is best to make very small and slow maneuvers.

Time Limit – This value sets the time limit for docking. When time runs out, a dialogue box will be displayed enabling the participant to either restart the mission, or exit the simulation (to Windows).

Fuel Limit – The fuel limit sets the amount of fuel carried in the fuel tanks. Once fuel is depleted, a dialogue box will be displayed enabling the participant to either restart the mission, or exit the simulation (to Windows).

Stars – This sets the number of stars that can be seen in the simulation.

Damage limit – The Damage limit sets the amount of damage that will be allowed before the mission ends. Damage is usually caused by bumping into the International Space Station. If the damage limit is reached, a dialogue box will be displayed enabling the participant to either restart the mission, or exit the simulation (to Windows).

> ── **IMPORTANT NOTICE** ──
> The settings (Skill Level, Time Limit, Fuel Limit, Stars, and Damage Limit) are saved to the file spacesim.ini that is stored in C:\Windows\System so they are retained even if SpaceSim is exited.

Advanced Mission Setup dialogue box

Setting various parameters in the advanced mission setup dialogue box enables more advanced mission features to be configured.

Pressing "more" on the mission setup dialogue box displays the Advanced Mission Setup. The Advanced Mission Setup dialogue box is shown on the next page.

Shuttle Attitude – This setting sets the initial Pitch, Roll, and heading (yaw) of the Orbiter. There is also a checkbox next to each setting. If one or more checkboxes is checked, the appropriate attitude setting(s) for the Orbiter Docking System will match the attitude of the Space Station's Pressurized Mating adapter, thus making it unnecessary to adjust these values prior to docking. This feature could make alignment adjustments (prior to docking) easier for some participants. This feature also enables participants to

mimic an actual mission scenario more closely where some of these alignments may already be made prior to final approach.
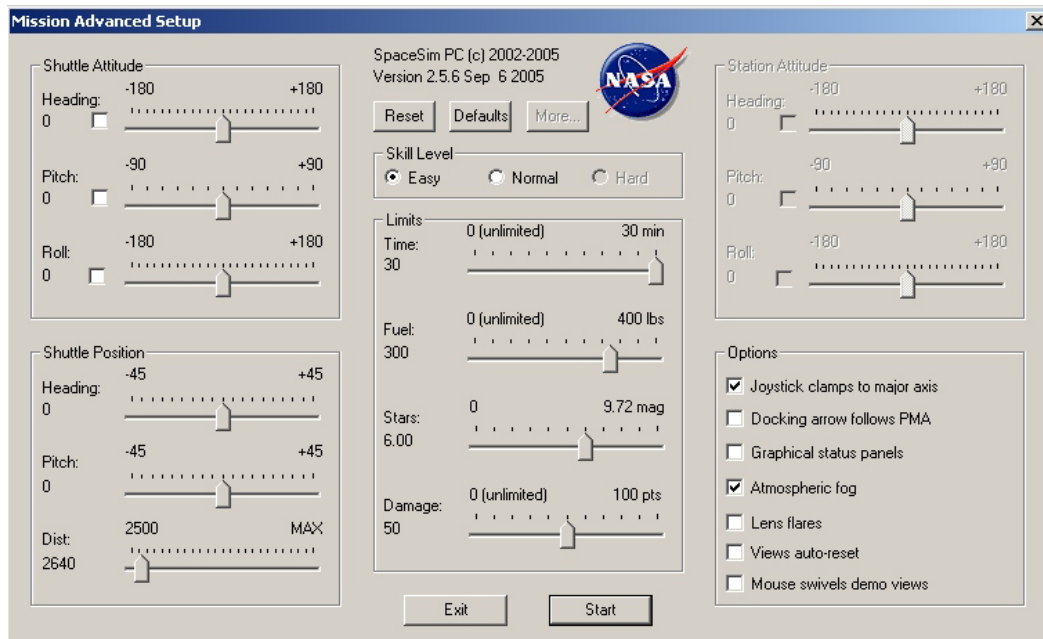
Shuttle Position – This setting sets the initial location of the Orbiter in relation to the International Space Station. It is possible to configure the Pitch, Heading, and Distance. The diagram below explains precisely how changing these values affect the location of the Orbiter with respect to the International Space Station. Care needs to be taken when changing the Initial shuttle position to assure that the distance isn't set too close. If it is, this condition would cause the mission to end immediately upon startup due to a collision.
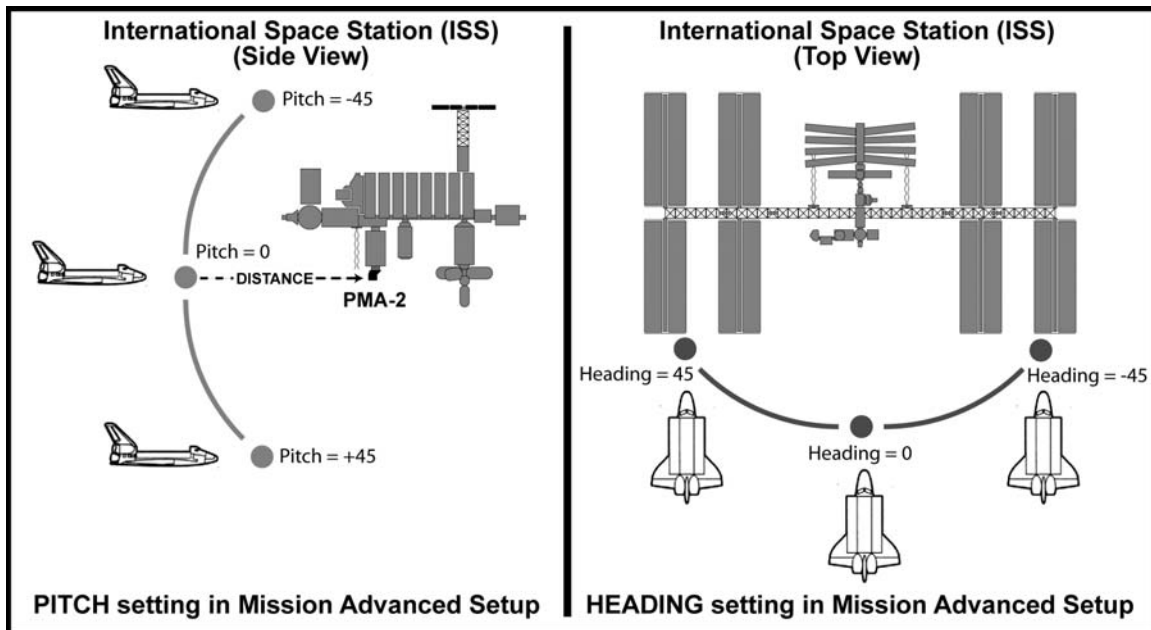
Skill Level and **Limits** - The skill level and limits have previously been explained.

Options

SpaceSim provides several options that may not be desirable for all users. These options change the way the controls function and look.

Joystick Clamps to major axis – If selected, the main joystick can limit values to only the axis with the largest offset to alleviate accidental drifting in 2-dimensions.

Docking arrow follows PMA – If selected, the docking arrow can follow the PMA around the screen. If not selected, the docking arrow remains stationary in the upper/center of the screen.

Graphics Status Panels – If selected, a graphical status panel is displayed. If not selected, a text-based status panel is displayed.

Atmospheric Fog – If selected, Atmospheric fog will add a level of realism to the Earth's atmosphere. On slower machines, turning this feature off may increase performance.

Lens Flare – If selected, a glow emanating from the Sun, as if viewed through a camera or helmet increases the immersion factor but could be distracting to some users.

Views Auto-Reset – If selected, the many views (FWD, AFT, Bay, etc …) reset to their default location each time a new one is chosen. If not selected, views remain at the last position.

Mouse Swivels Demo Views – If selected, the mouse can be used to look around (Ie. Swivel) some of the views.

┌─── **IMPORTANT NOTICE** ───┐
All values in the advanced mission dialogue box except Skill Level, Time Limit, Fuel Limit, Stars, and Damage Limit are NOT saved to a file but are saved in temporary memory. Therefore, these values are retained from mission to mission, provided SpaceSim is not exited but are lost when SpaceSim is exited.
└──────────────────────────┘

7.0 SpaceSim – Main operation

7.1 Mission Objectives

The Primary mission objective is to Rendezvous and Dock with the International Space Station (ISS). A supplementary mission objective is to perform a Spacewalk around the ISS and/or Orbiter. Many other mission objectives are also possible. Below are some additional ideas …

- Maneuver around the ISS to identify a particular module/component and what country developed it.
- Attempt to perform a docking using a limited amount of fuel.

- When working with a group, attempt to dock more accurately than anyone else (As determined by the data provided in the statistics box following a successful docking)
- Attempt to dock using the "Normal" skill level where acceleration of the Orbiter is added in response to engine firings.
- Attempt to dock using only the INTERIOR views (Forward View, Aft View, and Aft-Overhead view). In addition, use the Attitude Direction Indicator (ADI) instrument and the Centerline Camera as alignment aids. Use the Approach Rate and Range information on the display panel to aid with docking. This scenario provides the highest level of realism to an actual Space Shuttle Docking Mission.

7.2 A Tour of the Main Display Area

The illustration below shows a picture of the on-screen elements used in the "FWD" view. The elements available in the Main Display Area include …

Navigation Arrow – This arrow always points in the direction to the Docking Port (Pressurized Mating Adapter #2) on the International Space Station. Additional explanation is available under section 7.6 "Rendezvous and Docking Aids".
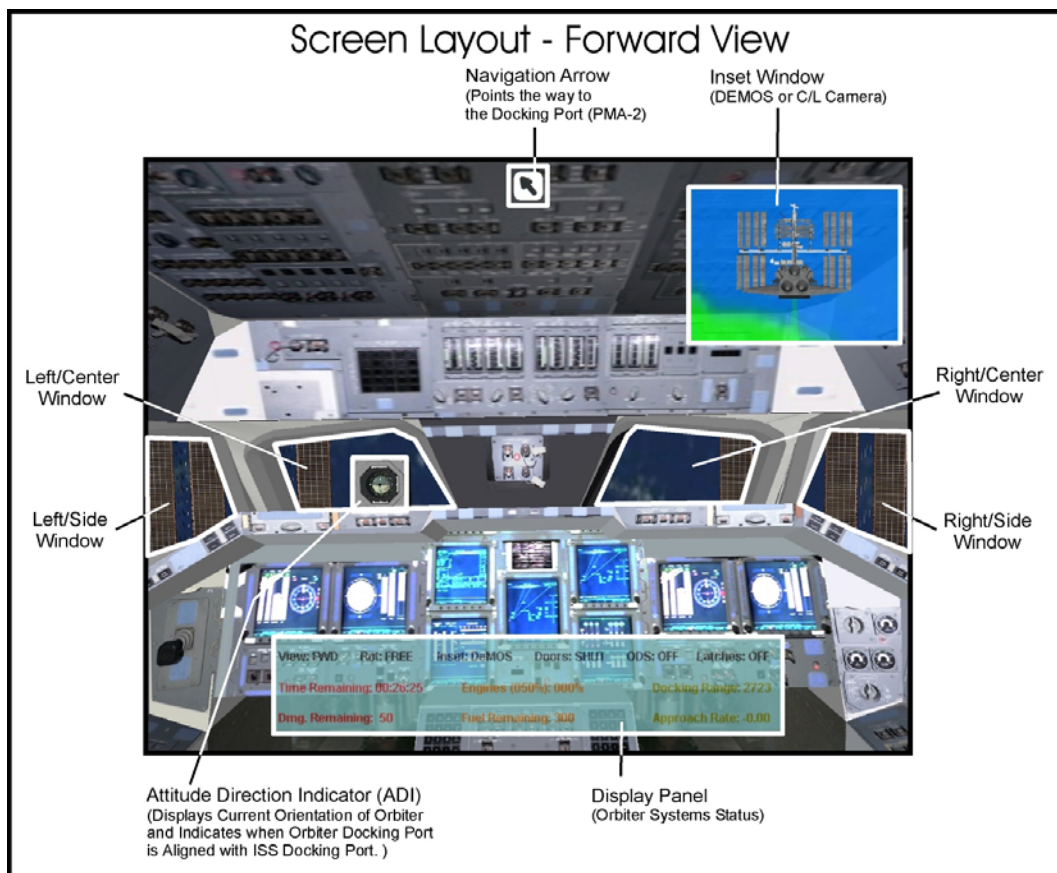
Inset Window – This Inset Window simulates two displays that are available to the Orbiter crew, or to the Mission Controllers on the ground to aid with docking.

- DEMOS Display - The DEMOS (**D**istributed **E**arth **M**odel and **O**rbiter **S**imulation) display is a 3-D graphic display that helps users visualize where the Orbiter, International Space Station and Earth are in relation to each other.

- Centerline Camera view (ODS Cam.) – The Centerline Camera view simulates the image from a camera mounted within the Orbiter Docking System to aid in aligning the ODS with the PMA#2 during the final stage of docking.

  Additional explanation for both of these displays is available in section 7.6 "Rendezvous and Docking Aids".

Attitude Direction Indicator (ADI) – This is an instrument on the Orbiter's FWD, and AFT Flightdeck that indicates the current attitude (Rotation) of the Orbiter in Pitch, Roll, and Yaw. This instrument also aids with orientation alignment for docking. Additional explanation is available under section 7.6 "Rendezvous and Docking Aids".

The illustration below shows a picture of the on-screen elements used in the "Aft" view.
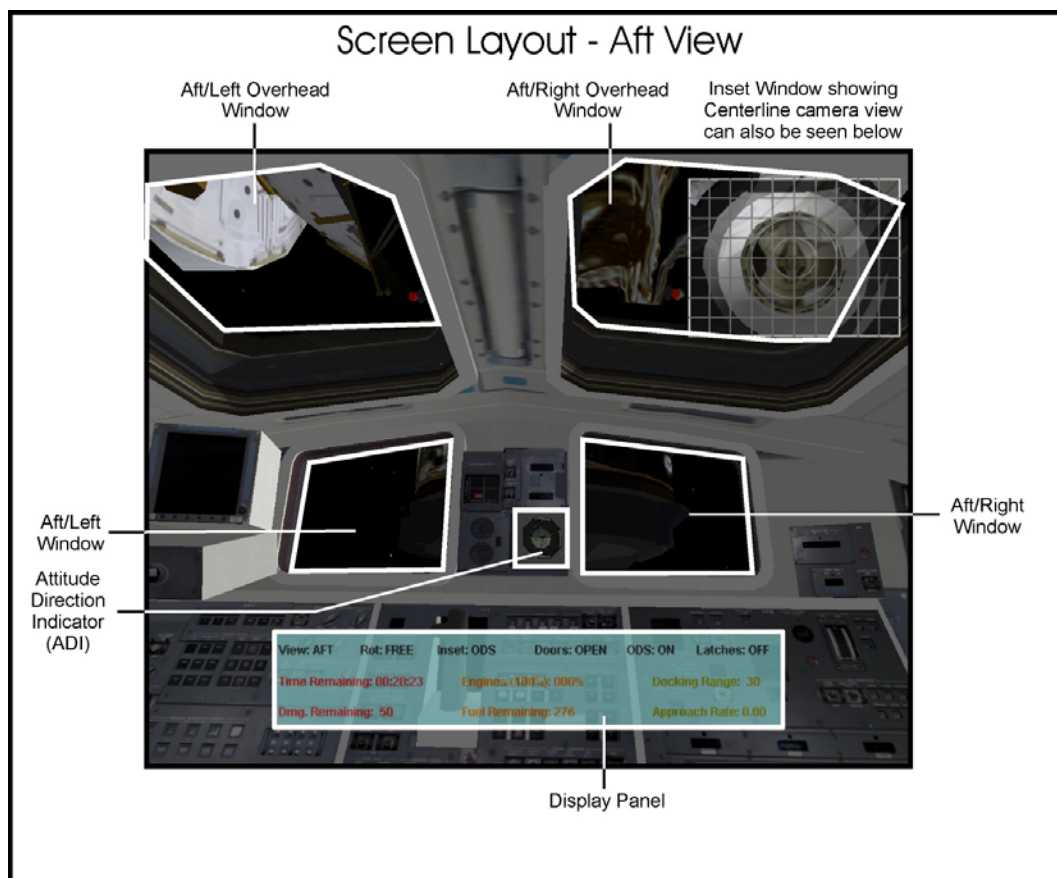
Display Panel – The display panel provides essential information about the Orbiter systems and status such as time, and fuel remaining, range and approach rate to the International Space Station's docking port, and the status of the Payload bay doors and Orbiter Docking System power among other things.

Left/Side Window, Left/Center Window, Right/Center Window, and Right/Side Window – These windows enable participants to peer outside the Orbiter to look at specific scenery outside their vehicle that could include the International Space Station, the surface of the Earth, or the blackness of Space.

7.3 Viewing Your Environment (View Selection)

"View Selection" related commands	
Change Views	F1, F2, Joystick Hat Switch Left, Right, Forward, Back

At the start of the simulation, the participant is placed in the "FWD View" on the Flight Deck of the Space Shuttle Orbiter. During a mission, they can select a large variety of different views in order to rendezvous and dock more accurately, or to perform many different mission scenarios.

The various viewpoints that are available in SpaceSim are listed in the charts and photos below and on the next page along with the associated joystick and keyboard controls that are used to select them.

Viewpoint	Joystick	Keyboard	Useful for
FWD View	Hat Switch – UP/DWN	F2	General Maneuvering
AFT View	Hat Switch – UP/DWN	F2	Approach & Docking
Payload Cam	Hat Switch – UP/DWN	F2	Adjust docking accuracy
EVA POV	Hat Switch – UP/DWN	F2	Spacewalking

Viewpoint	Joystick	Keyboard	Useful for
ISS Zoom	Hat Switch – Left/Right	F1	General Maneuvering
Orb Track	Hat Switch – Left/Right	F1	Moments before docking
PMA Track	Hat Switch – Left/Right	F1	Moments before docking
Approach Zoom	Hat Switch – Left/Right	F1	Approach
Docking Zoom	Hat Switch – Left/Right	F1	Approach & Docking

For the highest level of realism during a docking, participants should restrict themselves to only those views that can be observed by the astronauts themselves from within the Orbiter Flightdeck (FWD and AFT views). In addition, while not specifically a selectable view, a participant could peer out of the Aft-Overhead windows by selecting AFT view, and then using the mouse or trackball to tilt their view upward.

ISS Zoom, Approach Zoom, and Docking Zoom aren't a good choice for fine-tuning your docking alignment using the ODS Cam. Since the Inset window isn't available in these

three views – use FWD, AFT, Payload Cam., EVA POV, Orb. Track, or PMA Track instead.

SPACESIM'S MAIN VIEWS

FORWARD VIEW   AFT VIEW   PAYLOAD BAY VIEW   EVA VIEW

SPACESIM'S AUXILIARY VIEWS

ISS ZOOM VIEW   ORB TRACK VIEW   PMA TRACK VIEW   APPROACH ZOOM VIEW

DOCKING ZOOM VIEW
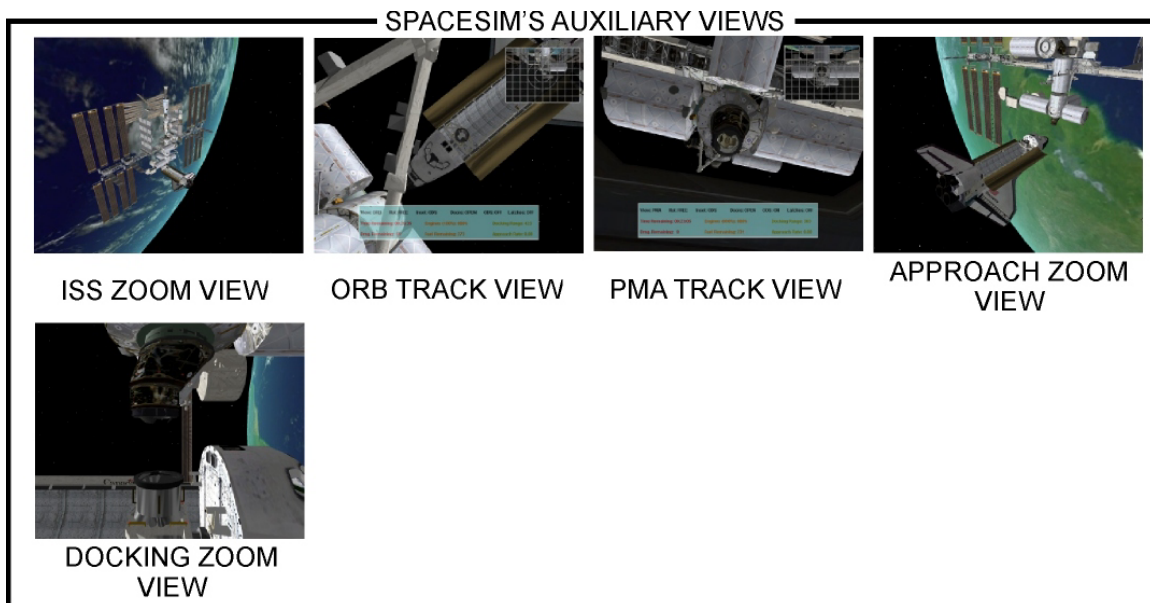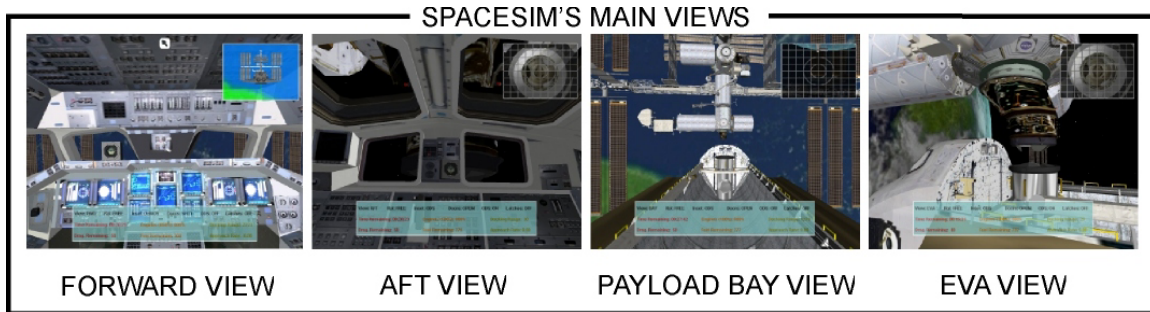
7.4 Moving around (User Navigation)

Moving around the Orbiter and out in Space (While performing a spacewalk) is easy and fun. A mouse or trackball can be used interchangeably to move around.

Not all views will enable a participant to move forward and backward. Some will only enable the view to be rotated.
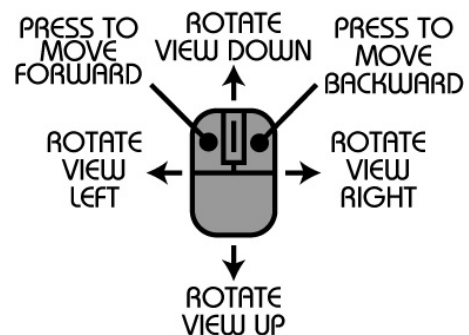
Getting stuck while moving around the interior of the Orbiter

Sometimes, while moving around the interior of the Orbiter (In FWD or AFT View only), it is possible to get stuck where it is not possible to move forward or backward. If this happens, it will be necessary to rotate the view while moving forward and backward a few times. If this is found to be taking too long, "R" could be pressed to reset the viewpoint.

7.5 Maneuvering the Orbiter (Orbiter Navigation)

The description that follows assumes the usage of a 3-Axis (i.e. where the handle can twist) Joystick. SpaceSim is capable of supporting other types of joysticks but since these other types aren't preferred, information on their utilization is provided in Appendix 1.

3-Axis Joystick

Maneuvering the Orbiter is a lot different than driving a car, or riding a bicycle. In Space, where there is no gravity and lots of wide-open space, The Orbiter is able to move in any direction (Left, Right, Forward, Back, Up, or Down) or rotate in any axis (Pitch Up, Pitch Down, Roll Left, Roll Right, Yaw Left, Yaw Right). In SpaceSim, a single controller (The Joystick) can be used to move in any of these directions.

The chart and diagram below assumes the usage of a 3-Axis Joystick with integrated throttle (The preferred standard).

Joystick with No Buttons Pressed		Joystick with Trigger Pressed	
Move Joystick	Orbiter Moves	Move Joystick	Orbiter Moves
Forward/Back	Forward/Back	Forward/Back	Pitch Up/Down
Left/Right	Left/Right	Left/Right	Roll Left/Right
Twist Left/Right	Up/Down	Twist Left/Right	Yaw Left/Right

3-AXIS JOYSTICK (TOP VIEW)
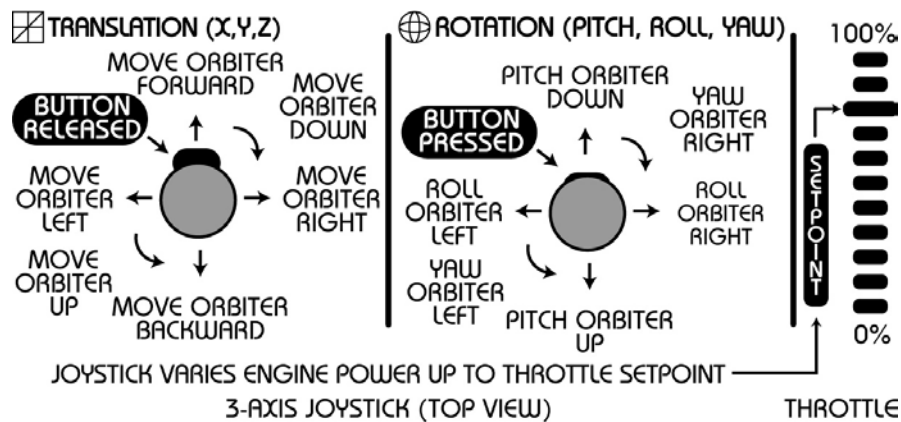
Throttle Operation

The Throttle Operation is different than may be expected but it is simple to understand. The throttle operation was designed to be more flexible and to provide better and more precise control of the engine firing. SpaceSim's throttle operation is particularly useful when operating in "normal" skill level where the vehicle accelerates in response to engine firing.

Quite simply, the throttle sets the MAXIMUM power that the engines are capable of generating but setting the throttle alone does not provide thrust. The Joystick must be moved in any of the three axes in order to activate the appropriate engines to create the desired movement. Engine power varies depending on how far the Joystick is moved in

any of the three axes's BUT Power can only increase up to the MAXIMUM level set on the throttle. Here are some examples of how the joystick and throttle work together to enable the participant to vary the thrust precisely.

Example 1 – Assume the Orbiter is 2000 feet away from the International Space station's docking port (The Pressurized Mating Adapter #2) and the participant wishes to approach fairly quickly. The throttle would be set to 100% (all of the way up), and the joystick would be pushed all of the way forward to generate the maximum thrust the Orbiter is able to provide.

Example 2 – Assume the Orbiter docking system's docking ring is 10 feet from the International Space Station's docking port (The Pressurized Mating adapter #2). It will be necessary to approach the final 10 feet very slowly and accurately to perform a successful docking. In this case, the throttle would be set to 25% (quarter of the way up) and the participant would provide gentle movements of the joystick on the desired axes. The maximum power produced by the engines would be 25% but it will probably be much less as a result of the joystick being just slightly pushed (nudged).
.
Single Mouse/Trackball operation

Single Mouse/Trackball related commands	
Toggle Joystick/Mouse device between Moving yourself, and Moving the Orbiter	**"s"**

While not recommend, it is possible to operate SpaceSim with only a single Mouse/trackball and no joystick. Operating in this way could be useful if a quick demo needs to be performed when a joystick is not readily available. A single mouse would be used for both moving and rotating the participant's view, and firing the Orbiter's engines. When using a single mouse, pressing "s" will toggle between moving and rotating the participants view, and firing the Orbiter's engines according to the chart below. The "+" and "-" keys would be used to increase and decrease maximum available engine thrust.

The Chart below illustrates how the mouse controls the firing of the engines (and thus the movement of the Orbiter) when "Orbiter Movement" is toggled on by pressing "s". Using the mouse for "Moving yourself around" is the same as previously described.

2-Axis Mouse

With Left Mouse Button Pressed		With Right Mouse button pressed		With Both Mouse buttons pressed	
Move Mouse	**Orbiter Moves**	**Move Mouse**	**Orbiter Moves**	**Move Mouse**	**Orbiter Moves**
Fwd/Back	**Move Fwd/Back**	**Fwd/Back**	**Move Up/Down**	**Fwd/Back**	**Pitch Up/Down**
Left/Right	**Yaw Left/Right**	**Left/Right**	**Move Left/Rt.**	**Left/Right**	**Roll Left/Right**

7.6 Monitoring Orbiter Systems and Status (SpaceSim's display Panel)

SpaceSim's display panel is the pilot's window into how the Orbiter is performing. See the illustration below. A description of each display element is shown below and on the next page and each display element is fully explained elsewhere in this document.

The default location for this panel is at the lower, center of the screen. If necessary, this window can be repositioned anywhere on the screen and it can be larger or smaller to accommodate almost any screen resolution and display device. See 6.1 – Regular Screen Setup.

View: FWD	Rot: FREE	Inset: DEMOS	Doors: OPEN	ODS: ON	Latches: OFF
Time Remaining: 00:27:30		Engines (099%): 000%		Docking Range: 2723	
Dmg Remaining: 50		Fuel Remaining: 300		Approach Rate: -0.05	

View – Indicates the current view selected such as "FWD", "AFT", "BAY", "EVA", etc …

Rotation – Indicates whether Rotation is locked "LOCK" or Unlocked "FREE".

Inset – Indicates the current display being shown in the Inset Window – either "DEMOS", or "ODS".

Doors – Indicates whether the payload bay doors are "Open" or "Closed"

ODS – Indicates whether the Orbiter Docking System (ODS) power is "ON" or "OFF".

Latches – Indicates whether the ODS Latches are "ON" (Latched) or "OFF" (Unlatched).

Time Remaining – Indicates the Time Remaining for the simulation if a Time limit is selected on the setup screen. Indicates the Elapsed Time if "Unlimited" time is selected on the setup screen.

Dmg. Remaining – Indicates the Damage Remaining for the simulation. Indicates the Current Damage level if "Unlimited" Damage is selected on the setup screen.

Engines – Indicates the current power setpoint for the engines (set by the throttle) as well as the actual engine power being created by a combination of the Throttle Setpoint, and the percent deflection (from center) of the Joystick..

Engines (099%): 000% ◄── Actual Engine Power being generated (Determined by Joystick handle)
                                   ── Maximum Engine Power Setpoint (Determined by throttle)
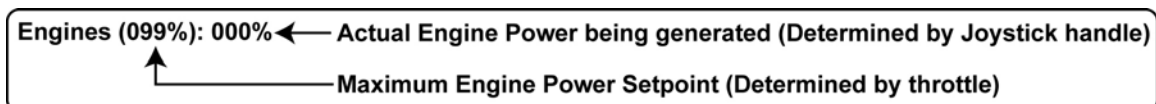
Fuel Remaining – Indicates the current fuel remaining if a fuel limit was set on the setup screen. Indicates the current fuel expended if "unlimited" fuel is selected on the setup screen.

Docking Range – Indicates the range to the docking port. This readout should read close to 0 when a user is docked to the International Space Station.

Approach Rate – Indicates the approach rate to the International Space Station's Pressurized Mating Adapter #2

7.7 Rendezvous and Docking Aids

Docking Arrow

The Docking arrow is an arrow that points in the direction of the International Space Station's docking port (Pressurized Mating Adapter #2). It was initially implemented to prevent participants from losing sight of the International Space Station and getting lost in Space. However, this docking aid is rarely needed due to the many other docking aids available in SpaceSim. However, it is available if it is needed.

Red Flashing Beacon lights on Docking Port (PMA2) and Orbiter Docking System (ODS)

When the Orbiter gets fairly close to the International Space Station's docking Target (PMA #2), it can be positively identified by the flashing, red lights that are positioned around it.

In addition, lights flash on the Orbiter Docking system (ODS) when it is powered up. These can be seen by peering out of the Aft Flightdeck windows and in some of the other views. .
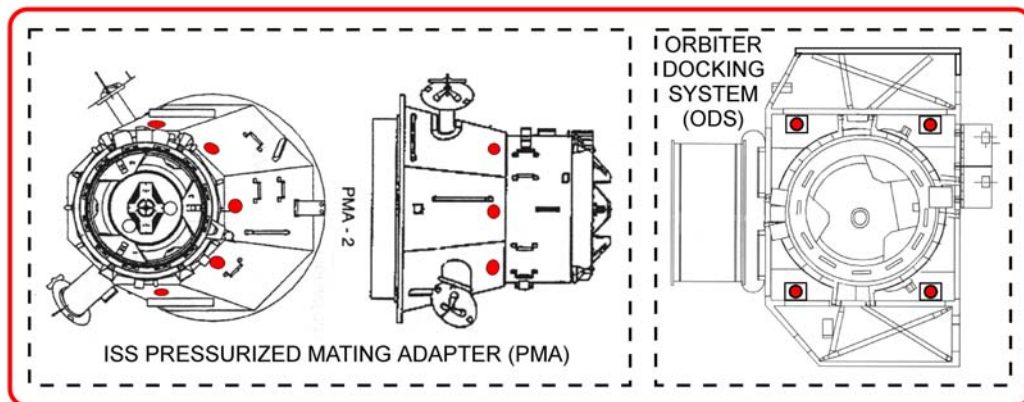
Display Panel readout of docking range and approach rate

The docking range and the approach rate continuously display the distance and approach rate to the docking target (The Pressurized Mating Adapter #2) on the International Space Station. This data is shown on the right side of the display panel as shown at right.
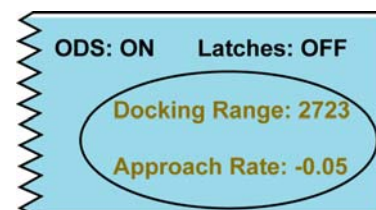
Inset Window – DEMOS display

DEMOS related commands	
Change Inset Window to DEMOS view	PgUP,PgDWN, Joystick Btn. #3
Zoom IN/OUT	Keyboard Cursor keys Up/Down
Change View Angle	Keyboard Cursor Keys Left/Right

The DEMOS (**D**istributed **E**arth **M**odel and **O**rbiter **S**imulation) display is a 3-D graphic display that was conceived and developed at Johnson Space Center for use in the Mission Control Center as a mission planning and visualization tool. During an actual Space Shuttle Mission, this orbiter display is driven by real-time telemetry from the Orbiter Downlink (OD) telemetry stream.
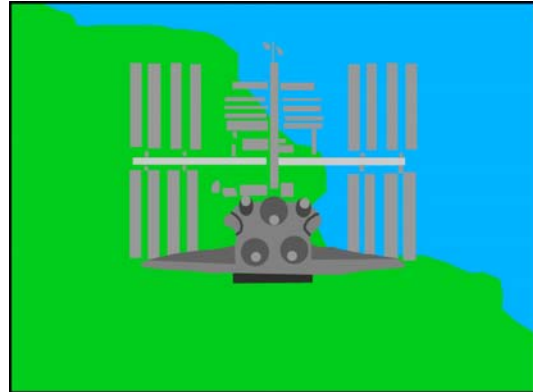
SpaceSim utilizes a simplified version of DEMOS to help users understand where the Orbiter, International Space Station, and the Earth are in relation to each other. The DEMOS display is provided in the INSET window.

The DEMOS window is also capable of displaying a visual indication of engine firing. See the illustration at right. Whenever the orbiter engines are fired to change position or orientation of the vehicle, a thrust plume can be seen coming from those engines that are required to provide the required motion. This visual indication of engine firing can only be seen in the DEMOS window and cannot be seen in the main window. This visual effect looks better if you zoom into the view as can be seen at right.
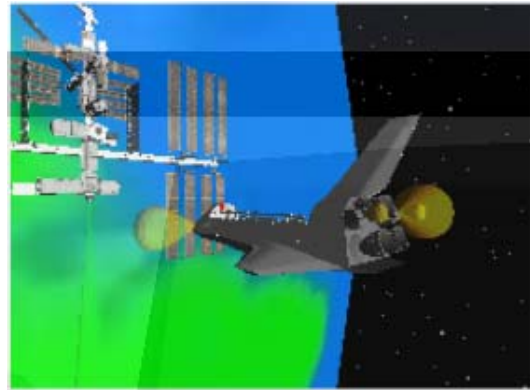
For more advanced users, the DEMOS window also provides a visual indication of the motion vector that indicates the total motion of the Orbiter vehicle. The motion vector is shown in RED in the DEMOS Window and indicates the end result of the total direction and speed of the Orbiter. Advanced users who know how to interpret this display may find it easier to dock in "Normal" mode where acceleration is added when firing engines.

Inset Window – Centerline Camera view

Centerline Camera related commands	
Change Inset Window to C/L Cam. view	PgUP,PgDWN, Joystick Btn. #3

The Centerline Camera view is a docking aid that the Orbiter crew uses to perform a final translational alignment with the International Space Station's Pressurized Mating Adapter. The Orbiter's centerline camera is mounted at the bottom of the Orbiter docking system (ODS). This camera is used to view an approaching docking target that is mounted within the International Space Station's Pressurized Mating Adapter. During the final phase of docking, the Orbiter crew aligns the center of the docking target with the center of the view from this centerline camera to enable a perfectly aligned docking
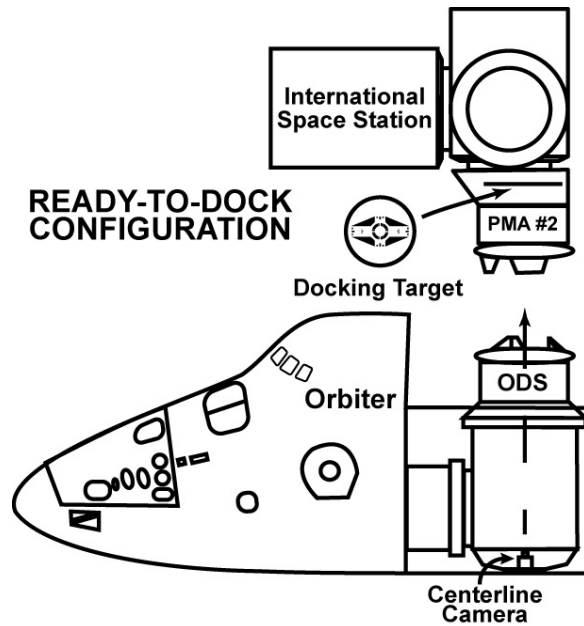
The illustration at right shows the location and placement of the Centerline Camera in the Orbiter docking system, and the placement of the docking target in the Pressurized Mating Adapter.

The illustration below demonstrates how the centerline camera looks when the target is perfectly aligned (Left) and when the target is misaligned (Right). Prior to docking, the user will need to maneuver the Orbiter in front of the Pressurized Mating Adapter until the docking target is positioned nearly in the center of the display as shown at Left. There is a little margin for error just as in a real docking, but it isn't much.
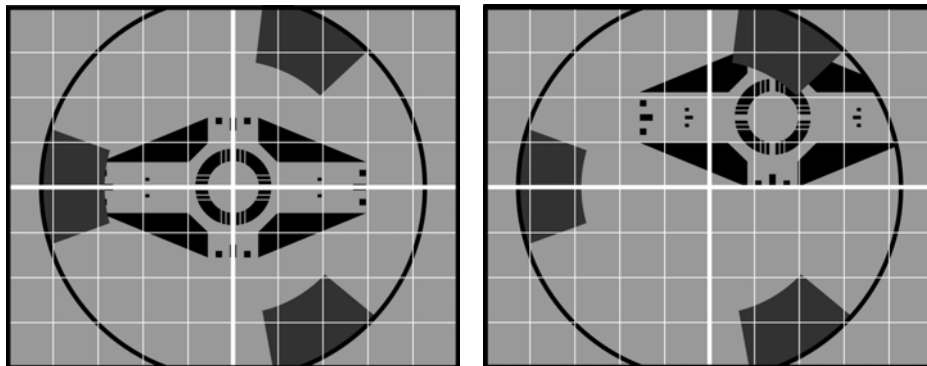
Attitude Direction Indicator (ADI) display on FWD and AFT Flightdeck

The attitude direction indicator is an instrument that is located on the Forward and AFT Flight deck and indicates the current attitude of the Orbiter in Pitch, Roll, and Yaw. The ball within this instrument will roll in response to any rotational maneuvers the user makes. This instrument has been enhanced with a visual indicator showing when the Orbiter is perfectly aligned with the Pressurized Mating Adapter. The drawing on the next page illustrates how this display looks when the ODS/PMA is perfectly Aligned (Left) and showing an example of how it could look when it is misaligned (Right).
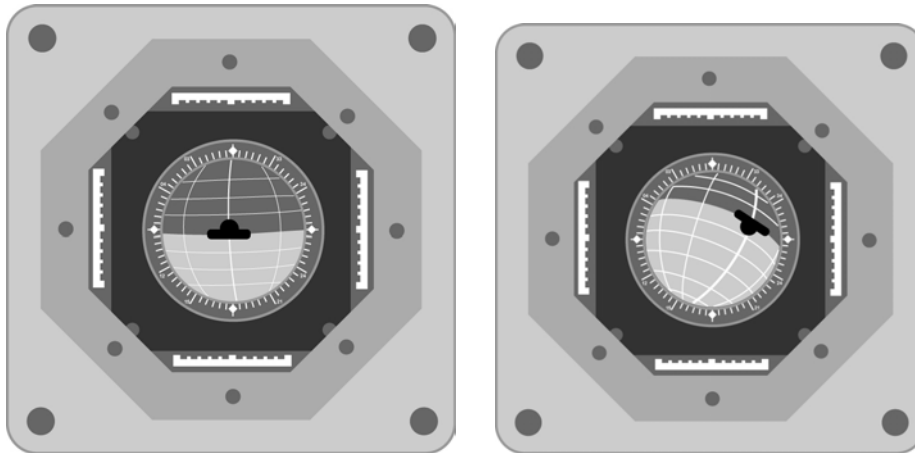
View selection

The selection of main views is one of the most important and most useful docking aids of all and SpaceSim provides a choice of numerous views to chose from. View selection is fully explained in section 7.3 "Viewing Your Environment (View Selection)".

7.8 Docking Procedure

DOCKING related commands	
ODS Power ON/OFF	F5, Joystick Btn. #5
ODS Latches Disengage (Undocking)	F7, Joystick Btn. #6
Rotation Lock/Unlock	F3, Joystick Btn. #2
Auto-Dock Engage/Disengage	F8, "a"
Engine firing	Joystick handle and trigger
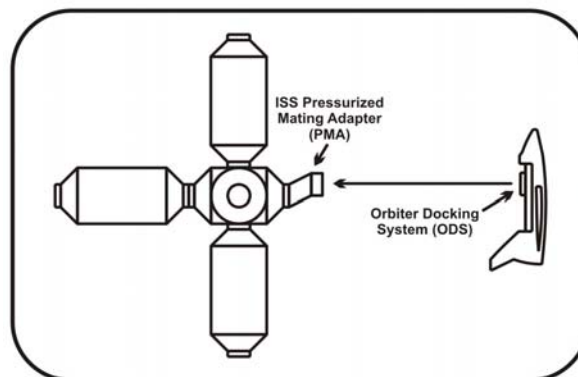
In order to successfully dock the Orbiter to the International Space Station's Pressurized Mating Adapter #2 (PMA-2), a number of criteria must be met. These are described below and on the next page …

1) **Payload Bay Doors Must be Opened** - The Payload bay doors must be opened to expose the Orbiter Docking System. Opening the Payload bay doors also enables light to reach the Centerline Camera that is mounted in the Orbiter Docking System, thus

activating its view in the Inset Window if it is selected. If a user fails to open the payload bay doors while attempting to dock, they will cause the Pressurized Mating Adapter to crash into the Orbiter, possibly ending the mission.

2) **ODS Power Must be turned On** – The Orbiter docking system power must be turned on prior to docking to energize the latches and other electronics contained within it. If a user fails to turn on ODS Power while attempting to dock, they will cause the Pressurized Mating Adapter to crash into the Orbiter, possibly ending the mission.

3) **ODS/PMA Must be aligned** – The Orbiter Docking System mounted in the Orbiter's Payload Bay must be aligned with the Pressurized mating adapter #2 that is attached to the International Space Station or the two components won't be able to "connect" properly.

4) **Orbiter's approach to PMA #2 must not be too fast** – If the Orbiter's docking system hits the International Space Station with too great a force, some damage could be sustained, possibly ending the mission. Approach slowly as a real docking is a very slow and carefully planned process.

7.9 Undocking

"Undocking" related commands	
ODS Latches Disengage (Undocking)	**F7, Joystick Btn. #6**

Following a successful docking, users are able to undock from PMA-2 to enable additional mission scenarios to be performed.

In order to undock from PMA-2, simply deactivate the latches by pressing the Joystick button #6 or by pressing F7 on the keyboard and then fire the engines to pull away from the station. Following undocking, a user may dock again.

7.10 Events that can end or interrupt a mission

There are three types of events that can end a mission, or at least interrupt it. These are described below …

1) Catastrophic events that include crashing into the International Space Station until the damage limit is reached, running out of time, or running out of fuel. In the case of a catastrophic event, the user is presented with a dialogue box that displays the problem and enables them to either restart the simulation from the beginning, or exit the simulation.

2) The only non-catastrophic event that can cause an interruption of the simulation is a user-forced exit (to Windows) caused by pressing the "x" key. In this case, a user is presented with a dialogue box that displays the problem, and enables them to restart the simulation from the beginning, continue the simulation where they left off before the problem, or exit the simulation.

3) The final event that can cause an interruption in the simulation is a successful docking in which the user is presented with a dialogue box that displays their

docking status and enables them to restart the simulation from the beginning, continue the simulation following their docking so they can undock if desired, or exit the simulation.

7.11 Mission Summary Window

The mission summary window (Examples shown below) pops up immediately following any event that can end or interrupt a mission as explained in the last section.

The Components of the Mission Summary window are as follows …

Docking Status – Indicates the reason that this box popped up. If it popped up as a result of a successful docking, it will indicate "Success". Other entries in this box could be "Aborted", "Crashed", "Out of Time", " Out of Fuel".

Time Elapsed – Indicates the total time that was required for this mission.

Fuel Expended – Indicates the total fuel expended during this mission.

Damage Sustained – Indicates the total damage sustained during this mission.

Docking velocity – Only if docking was successful, indicates the speed at the moment of docking, otherwise, this entry is blanked out.

Docking Attitude – Only if docking was successful, indicates the difference between the International Space Station's PMA-2 attitude, and the Orbiter's ODS attitude. In other words, indicates how well the user was able to rotationally align the ODS to the PMA attitude in Pitch, Roll, and Yaw. For all situations other than docking, this entry is blanked out.

Docking Position - Only if docking was successful, indicates the difference between the International Space Station's PMA-2 position, and the Orbiter's ODS position. In other words, indicates how well the user was able to translationally align the ODS to the PMA position in X, Y, and Z. For all entries other than docking, this entry is blanked out.
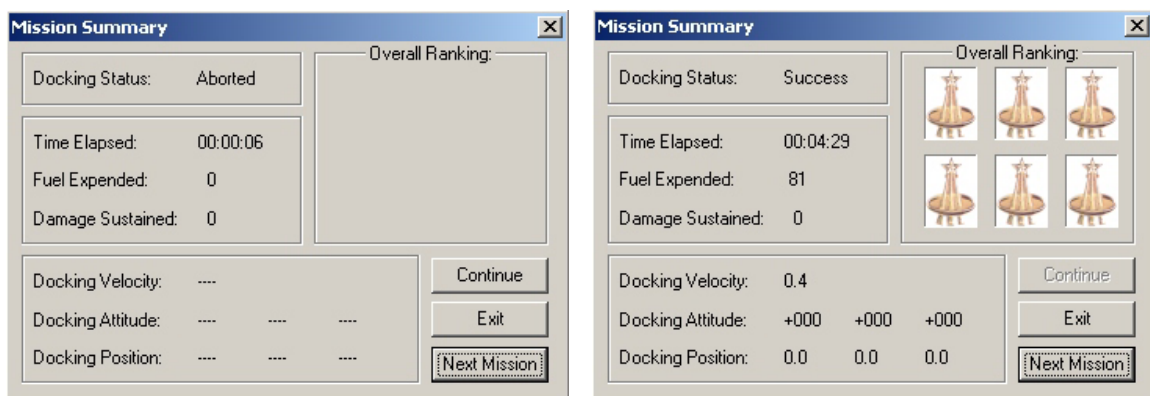
Overall Ranking – SpaceSim takes all of the performance data into account to give the user a final ranking at the end of each mission that results in a successful docking.

Depending on how well the user does, they can get as little as no pins, or as many as 6 pins.

7.12 Audio Commentary and Sound Effects

Special Effects and audio commentary are heard throughout SpaceSim to enhance the experience. Sound effects include background instrumentation hum, key press "beep", payload bay doors open/close motor, and an explosion sound (In response to a collision).

Audio commentary includes verification of view selection, verification of payload bay door open/close, verification of view selection, verification of docking success, verification of mission failure, etc …

7.13 Advanced Features

For advanced Users, SpaceSim is capable of immersing the user in a Immersive Virtual Reality Environment using full Head-tracking, and a Virtual Reality Head-Mounted Display. A block diagram of a typical system is provided in Appendix 2. It should be noted, though that SpaceSim is not capable of producing a stereo image so the single graphical output from the computer will need to be fed to the MONO input of the HMD, or a splitter will need to be used. The end result is that a single video channel will need to drive both HMD channels. In order to use Virtual Reality, you will have to select the appropriate tracker you are using on the sensor setup screen after you startup SpaceSim, and then select the appropriate baud rate and COM: Port. Finally, Press "Home" or "f" to toggle ON the V.R. Tracker in order to use rotational data from the V.R. Tracker rather than the Mouse.

7.14 SpaceSim Curriculum (Under Development)

Curriculum Enhancement Activities are planned for SpaceSim to enable the Orbiter docking simulation to be integrated into regular activities in classrooms, museums, science centers and other educational venues.

The development of the Space Shuttle has spawned a whole new generation of schools, museums, and science centers who want to offer their students a high-fidelity Space experience right at their facility. A constantly growing number of educational facilities across the country provide their students with an experience of a lifetime by constructing a permanent Space Shuttle/Space Station Mission Simulator on-site and hosting a summer camp. The SpaceSIm Software is a perfect choice to provide a high degree of realism and authenticity for any Permanent Space Shuttle Mission Simulation and/or Summer Camp program.

8.0 Special features that make Spacesim useful for public exhibitions and museums

SpaceSim has been especially designed to bring the excitement and challenge of Space Exploration to the general public at public exhibitions and educational conferences. Several features have been built into the SpaceSim software that makes it expecially well suited for public venues. These features include:

8.1 Exclusive Joystick/Trackball Operation

We all know that kids with keyboards can sometimes spell disaster in the form of erased hard disks, unauthorized configuration changes, and unauthorized internet access (If the computer is connected to the Internet). To help prevent this problem, all SpaceSim missions can be conducted using only the joystick (with integrated buttons and throttle) and trackball (or mouse). Once the simulation is started and configured by an attendant at the beginning of the day, the keyboard can be placed out of reach or locked up. The simulation will continue to run all throughout the day until it is time to shutdown at the end of the day.

8.2 Demo (Attract) Mode

Demo Mode related commands	
Launch Demo Mode	**F9, D**

SpaceSim is equipped with a demo mode which is sometimes referred as an "Attract" mode. The Demo (Attract) mode displays the name of the simulation and then shows a docking and then undocking in under 3 minutes. Whenever possible, it is always best to provide personalized, interactive demonstrations of SpaceSim at all exhibit sites and events. However, the purpose of the Demo (Attract) mode is to demonstrate the capabilities of SpaceSim at events where crowd volume would be too great to enable personalized, interactive demonstrations. The Demo (Attract) mode could also be used to attract people to the simulation at periods when crowd volume is very low and no one is currently using the simulation. Finally, the demo mode could be used whenever the operator/attendant has to leave the simulation for short periods such as to eat or use the restroom. The demo (attract) mode is executed by pressing the F9 key on the keyboard. Demo mode will continue indefinitely until the joystick trigger is pressed.

8.3 SpaceSim usage file

SpaceSim automatically creates a usage log file everytime it is run. The usage file automatically lists the number of people that fly SpaceSim during each day. The SpaceSim usage log is useful for reporting the level of usage at meetings, and on reports. The usage log will display the usage data in the following form …

Date: Month, Day @ Time, # Missions ending normally, # Missions ending with a docking, # Missions ending where fuel ran out, # Missions ending with excessive damage, # missions Aborted

Since SpaceSim stores a tally of the number of flights in internal memory until the simulation is exited, and then dumps the total out to the file "SpaceSim.log" at Exit, there may be several entries for the same day if SpaceSim was exited and restarted several times during a single day.

If you wish to clear this "SpaceSim.log" file, simply delete it from the SpaceSim directory on your hard disk, and then it will be created and appended the next time SpaceSim is run.

If you run the simulation from CD or some other non-writable media, a usage log will not be created.

The usage file can be read using any text editor.

8.4 SpaceSim Auto-Dock mode

Auto-Dock related commands	
Auto-Dock Engage/Disengage	F8, A, a

Pressing F8, "a", or "A" at any time during a mission initiates an autodock sequence that causes the Orbiter to dock automatically. This feature can be engaged and then disengaged, if for instance, it is desirable for the computer to control the initial approach to the International Space Station and then have the participant control the final moments before docking. This feature could also be useful for handicapped students who may not be able to perform a full docking but may be able to perform the final moments prior to docking.

Appendix 1 – Using Additional Mouse/Joystick devices

While not preferred, it is possible to use a 2-axis joystick with SpaceSim. This could help some users save on the cost but is a little harder to get used to due to the extra button that has to be learned. For users who go this route, it is important to find a 2-axis joystick with a 4-way hat switch on the top of the handle unless you can use F1 and F2 on the keyboard.

2-Axis Joystick

Joystick with NO Buttons Pressed		Joystick with Trigger Pressed		Joystick with Button #2 Pressed	
Move Joystick	**Orbiter Moves**	**Move Joystick**	**Orbiter Moves**	**Move Joystick**	**Orbiter Moves**
Fwd/Back	Move Fwd/Back	Move Fwd/Back	Pitch Dwn/Up	Fwd/Back	Move Up/Down
Left/Right	Move Left/Right	Left/Right	Yaw Left/Rt.	Left/Right	Roll Left/Right

Appendix 2 – Virtual Reality System Block Diagram

SpaceSim Virtual Reality System Connection Diagram

Ascension Technology, Inc.
Flock-Of-Birds
Electronics Unit
V.R. Head Tracker

To
Transmitter
Cube

Ascension Technoloogy, Inc.
Transmitter Cube
Permanently Mounted
near HMD

Virtual Research, Inc. V6
Receiver Cube Mounted
on top of HMD

Serial
Port

Flock of Birds

FLY   STDBY   XMTR

From
Receiver

Virtual Research, Inc. V6
Head Mounted Display (HMD)

Power

Keyboard

Mouse

USB
1

Computer
Back
Panel

USB 2

Virtual Research, Inc. V6
HMD Control Box

Virtual Research
Monitor Output   HMD

"Mono" Eye Input
(Or use splitter)
VGA In

3-Axis Flightstick
with integrated
Throttle

Mouse or Trackball

Open-gl Graphics
ATI and Nvidia Tested
(128 MB Onboard Memory)

Soundblaster Compatible
Sound Card

NETWORK
TECHNOLOGIES
INCORPORATED
VOPEX-2V-H

1-In, 2-Out or
1-In, 3-Out
Video Splitter

VGA
IN
"COM."

VGA
OUT "1"

VGA
OUT "2"

VGA
OUT "3"

Spectators
(Attract)
Display

Stereo Speakers

Operators
(Coordinators)
display

Appendix 3 – International Space Station Assembly Diagram

Appendix 4 – SpaceSim Quick Reference Card
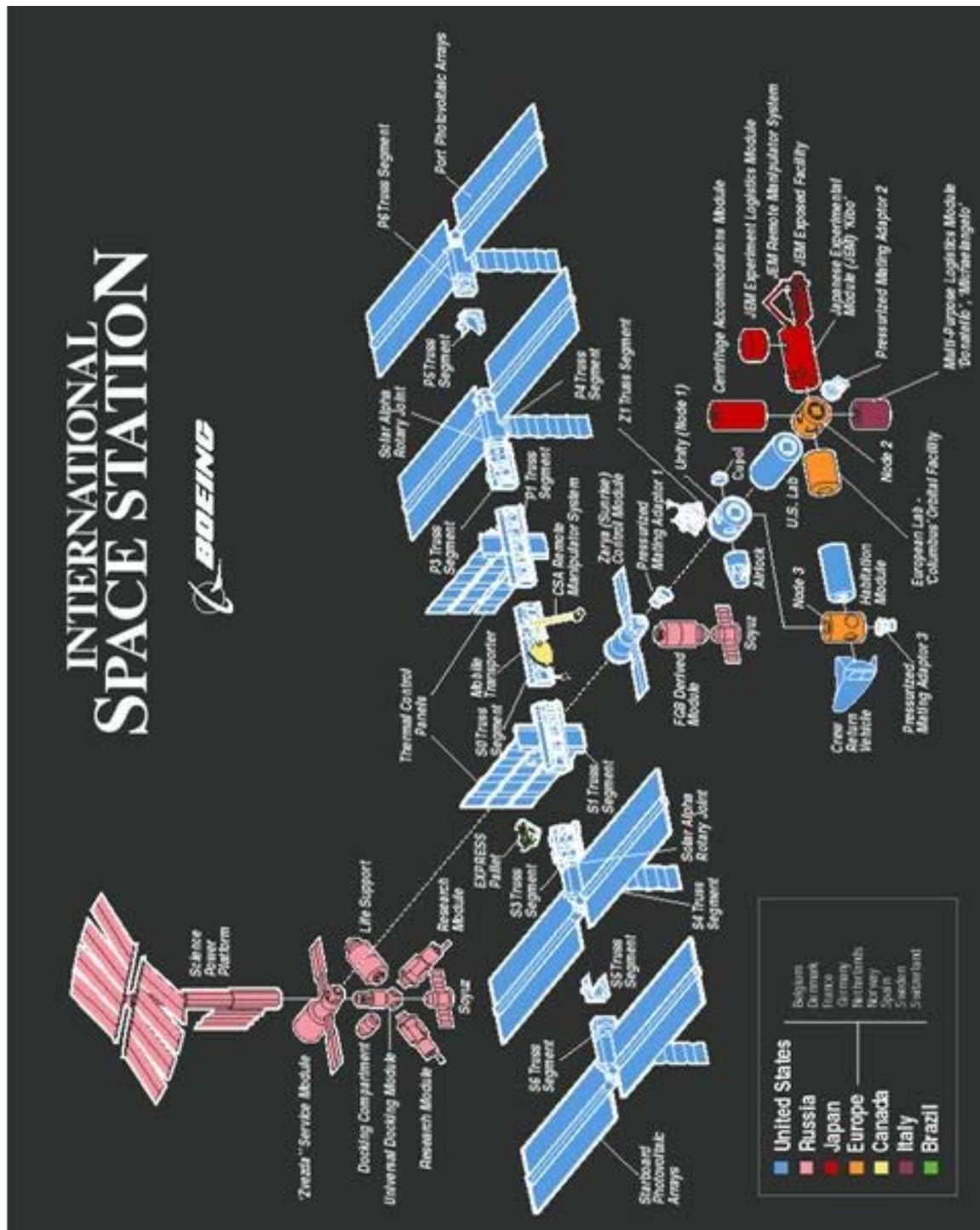
Here is a Quick Reference Card that was developed to help users operate the software.